A Work Project presented as part of the requirements for the Award of a Master Degree in Finance from the NOVA – School of Business and Economics.

US ENERGY POLICIES AND THEIR EFFECTS ON SOLAR ENERGY COMPANIES

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JANUARY 2019

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Abstract

This thesis aims to analyze how the different US energy policies and other events affected the investor's decisions and, consequently, the share prices of the various solar companies on the days where the news became publicly available. With the conclusions drawn from the previous analysis, this study tries to understand if the investors were aware of the implications of the studied policies in the future of the solar industry and the environment.

Keywords: US energy policies, renewable energy, solar companies, solar panel tariff, trade war

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List of Acronyms and Definitions

APAC – Asia-Pacific

EPA – Environmental Protection Agency

EMEA – Europe, the Middle East and Africa

EU – European Union

IEA – International Energy Agency

Latam – Latin America

RE – Renewable Energy

REIT – Real estate investment trust

UK – United Kingdom

US – United States

Photovoltaic (PV) solar panels – PV panel is a group of **PV solar modules** that absorbs the energy from the sun (photons) through the **PV solar cells** and generate electricity. The amount of electricity generated depends on the material of the solar cells, which usually are **wafer-based crystalline silicon cells** or **thin-film cells**, on the total number of solar cells in the PV panel and it also depends on the intensity of the sunlight. Regarding the **wafer-based crystalline silicon solar cells**, electronic wafers are tinny slices of a semiconductor material, which in the case of these solar panels are the crystalline silicon in one of its two types, producing, consequently, two different PV panels: the **monocrystalline silicon PV panels**, formed by a continuous crystal silicon cut into bars to create the wafers, and the **poly-crystalline silicon PV panels**, the wafers are formed from small crystals melted together. The **thin-film cells** are similar to the wafer-based cells concerning the structure and the functionalities, but instead of silicon, the PV material used is cadmium telluride or copper indium gallium diselenide.

Photovoltaic glass – PV glass is glass with photovoltaic solar cells incorporated that allows the conversion of sunlight into electricity. This glass can be used, for example, in the roof or walls. **Solar curtain** w**alls** are walls made of transparent photovoltaic glass which allows generating electricity from the capture of sunlight at the same time as used as a building material with the same sound and thermal isolation and natural light entrance as a conventional glass.

Solar power system – It is a system composed of PV panels, a **power inverter** which converts direct current into alternating current and a **racking system** to keep the PV panels in the right place.

Solar EPC (Engineering, Procurement and Construction) – It is a type of contract between companies where one party is responsible for the design of the project and the procurement, construction and commissioning of the power plant. Then, when the power plant is concluded, it is handed to the owner, the other party.

Solar hot water panel – It is a panel that absorbs the light from the sun through a solar thermal collector and then converts the sunlight into heat, heating the water inside of the reservoir.

1. Introduction

The world is getting every day more and more electrified which is desirable for the sustainability of the world's future and the environment since it reduces, in part, the utilization of fossil fuels, one of the primary causes of pollution. However, this only represents a real effect in the future if the generation of electricity come from carbon-free sources and not from coal, oil or natural gas. Otherwise, despite being in another phase of the process, the combustion of fossil fuels was still happening and, consecutively, still causing pollution. The carbon-free energies are all the different types of renewable energies and, also, nuclear power. The last one, although it is cheap, has many potential health and safety risks. Therefore, all these reasons, together with the decrease in renewable energy costs and improvement in renewable energy efficiency, in the last decades, had contributed to improving the share of the generation of energy from renewable sources and it is expectable that these share improvements will continue to occur in the future.

In 2008, the share of renewable energy in the EU total energy consumed was 11.1% and in the US was 9.8%, while in 2016 it was 17.0% and 12.3%, respectively. According to the EU's Renewable energy directive, which specifies the national renewable energy targets committed by the different EU members, the goal in the EU is 20% for 2020 and 32% for 2030. Relatively to the US, there are not settled renewable energy targets for the future, yet it is expectable a share of 20% in 2020 too. Furthermore, China has a committed renewable energy share target of 35% for 2030. Taking into account these numbers, it is possible to conclude that the renewable energy industry is growing

every year and there is space to grow even more. In fact, during the 2016 year, it was added more 164 GW to the existent renewable energy capacity (2,139.5 GW), representing an increase of 7.7%.

The renewable energy industry can be divided according to the renewable resource used, such as water, wind, solar energy, biomass, geothermal or other, and it can, also, be divided according to the segments where the energy will be consumed, for example, to produce electricity, to heating and cooling or to use it as fuel.

As said before, in 2016, it was added 164 gigawatts to the existent renewable energy capacity, of which 74 GW refers to additions on solar capacity (representing a growth of 50% around the world, half of which was in China) and 52 GW on wind capacity. The PV capacity addition, in 2016, was for the first time, higher than the addition in coal capacity, which usually was the energy with the highest growth. From 2011 to 2016, the solar PV capacity grew 260 GW and it is expectable that it will increase more 438 GW until 2022. This fast expansion in the past decade was determinant to choose solar energy companies instead of other renewable energy companies for this thesis.

In this thesis, it will be studied the impact of the different US energy policies and, also, some important events related to the solar industry on the prices of the selected solar companies which constitute the SUNIDX Index. For that, besides the analyzes of the price evolution through time from the day where the news became publicly available, it was used statistical analysis for the specific periods where those different policies where implemented and compare the results to the antecedent and following periods. In some cases, a linear equation was also computed to complement the analysis.

The main events chosen to be analyzed in this study were the trade war between the US and China, the 2016 US presidential campaign and the Donald Trump's election, and also the acceptance and withdrawal of US from the Paris Agreement. Regarding the US energy policies, it was chosen the major Obama administration's policy on energy and environment, namely the clean power plan and two of the US federal policies for solar companies, the renewable electricity production tax credit and the business energy investment tax credit.

From this thesis, it was possible to conclude that investors are, most of the times, well aware of the implications of these studied policies and events on the future of the index constituent companies and the future of the solar industry in general since the indexes prices, usually, varied as expected when there were unexpected disclosures of news related to these themes.

2. Literature review

The revised literature was based on themes like the investor's behavior and the non-financial factors that may affect the investor's decisions with a focus on specific factors for the solar industry. For that purpose, it was necessary to start the literature review with a definition of what an investor is. So, an investor is, usually, described as a person who decides to transfer part of the current consumption to the future with the expectation of consuming more in the future than what he or she could have consumed today.

There is significant evidence that investors are influenced by other factors too, rather than the most straightforward evaluation of the financial opportunities, at the time of their investment decisions. Besides, according to Bergek, Mignon and Sundberg (2013), there are different types of investors that decide to invest in the solar PV industry. From the total investors considered in the paper, 52% were sole traders, 18% were non-energy publicly-owned organizations, 12% were associations, 8% were utility companies and the remaining 10% were other types of companies. These different investors' groups have different technical and financial resources, different experiences of investing in similar investments and, also, they have different propensity to risk and different knowledge about the industry. So, the impact of the factors considered may be different according to the different investor's group.

For Masini and Menichetti (2012 and 2013), investors when deciding if they will invest in renewable energies and, also, when deciding in which renewable energy technology they will choose to invest, they have, also, the following factors into account: (i) the investor's a priori belief for each renewable energy technologies and their regulatory environments since investors tend to

choose the ones in which they have more confidence and the existing policies are more effective; (ii) the socio-economic and political environment where the renewable companies operate as it was concluded that during political uncertainty times and economic downturns, investors tend to invest less in innovation as it is riskier; (iii) the willingness of the investor to invest in new technologies still in development; and (iv) the investor's knowledge about the operational process of renewable energy technologies allows the investors to make investments above average in riskier projects. In both papers, it can be concluded that the different policies applied to the renewable energy sector and their effectiveness have a considered impact on the investor's decisions.

During the literature review, many papers, about the implementation of the different US policies for renewable energy and their effectiveness, were analyzed. Abdmoulehn, Alammari and Gastli (2015), Schaffer and Bernauer (2014) and Kilinc-Ata (2016) divided these policies into investment or generation policies, according to their implementation focus. The investment-based instruments highlighted were: (i) investment incentives for RE companies, for example, a tax reduction or a tax credit; (ii) low-interest loans provided by financial institutions with the aid of a public subsidy; and (iii) investment grant tender. While the generation-based tools were: (i) feed-in tariffs consisting of a better price for the electricity generated from renewable sources; (ii) long-term capacity contracts tender; and (iii) quotas which in the US it is known as renewable portfolio standards and it is defined as the minimum share of electricity generated from renewables that the competent authority determines for the region.

Furthermore, De Bondt (1985) concluded that, in the same way as people, frequently, in their life, tend to overreact to unusual situations where the course of actions changed, the investors do the same. The empirical evidence, in the paper mentioned lastly, showed that the stock prices were, in fact, affected by the disclosure of unexpected news related to the companies in question.

So, for this thesis and according to all the revised literature, it will be studied the impact of the different US policies on energy and environmental issues in the stock price of the solar companies and it will also be considered the effects of some relevant news related to the solar industry.

3. Model

3.1. Methodology

To understand the effect of the different US energy policies on solar companies, in this thesis, it was used the MAC Global Solar Energy Stock Index (ticker symbol: SUNIDX)[1] as the group of companies where these policy effects will be studied. However, and as explained next, this index is composed of different types of solar companies and, also, not all companies have operations in the US, so it is predictable that the same policy has different impacts on those different types of companies. So, to prevent the possibility of the various effects offsetting each other's as a whole, it was created smaller indexes that would group the companies of the same type from the initial index. The methodology behind the indexes will be explained next.

The MAC Global Solar Energy Stock Index is an index, currently, composed of 23 stocks listed on stock exchanges of 6 different markets (Germany, Hong Kong, Norway, Spain, Switzerland and US). It is a total return index, so the dividends or other cash distributions are, by definition, reinvested into the index, and it uses the modified market capitalization weighting method. Moreover, it was launched on March 31, 2008, with the value of USD 1,000.

Any publicly-traded company related with the solar industry is considered for entering the index at the rebalancing and reconstitution day which happens every quarterly. However, only the ones that comply with the following requirements will be added to the existent companies: (i) a company must have more than one third of its revenues coming from the solar business; (ii) it must be listed on a developed market stock exchange, with no restrictions for the localization of the issuer operations; (iii) its market capitalization must be higher than USD 150 million and the 1-month average daily trading value must be higher than USD 750,000; and (iv) it must have been at least one month since the company's initial public offering (IPO). If an already constituent company

[1] As investors cannot directly invest in an index, it was needed to create a security that tracks the index and, at the same time, allows investors to buy and sell it on the market, like an individual stock. This marketable security was created with the designation of exchange-traded fund (ETF). For this index, the correspondent ETF is the Invesco Solar ETF which is traded on the New York Stock Exchange ARCA (Ticker symbol NYSE ARCA: TAN).

does not meet these requirements, except for the two conditions in (iii), the company will be excluded from the index also on the reconstitution day. Additionally, there are exceptional circumstances, such as delisting, a trading suspension, a merger, an illiquidity or bankruptcy situation, where the company will be automatically excluded from the index. Concluding, besides the historical constitution of the SUNIDX Index is not publicly available, it is expectable that the composition of the index may have suffered significant changes during its lifetime.

For the smaller indexes, as it is not possible to know the historical constitution of the SUNIDX, these restrictions will not be counted, and the companies will always be the same as the current ones. However, to avoid survivorship bias, it will only be analyzed a period of three years. Another difference between the two types of indexes is the weight of the companies, while in the calculated indexes, the importance of each company is fixed (equally division between companies), in the SUNIDX Index, the weights are rebalanced every quarterly according to their market capitalization (price per share x number of outstanding shares) and the exposure factor, which depends on the group where the company is inserted. The exposure factor can be 0.5 or 1 depending if the company is a medium-play, companies with solar business revenues between one third and two-thirds of their total revenues, or a pure-play, companies with revenues from the solar business above two thirds, respectively. The adjusted market capitalizations, resulting from the multiplication of the full market capitalizations with the exposure factors, will be divided by the sum of all the companies forming the index weights that might be adjusted using an algorithm if the individual weights exceed the threshold of 10% and if the addition of the individual weights above 4.5% exceeds the limit of 45%.

As said before, it is a diversified index since it includes companies from the entire solar value chain and, also, because all the solar technologies available are present, for example, crystalline photovoltaic solar panels, transparent photovoltaic glass and solar thermal panels. Some companies produce the raw materials and do the manufacturing part, others are responsible for the installation or the operation of the solar plants and there are also the investors of the solar projects. Furthermore,

producers of related solar equipment, such as encapsulates and power inverters, may as well make part of this index. Table 1 shows the diversity present in the 23 SUNIDX companies, as well as their correspondent weights used in the index calculation.

Table 1. List of companies that were part of the index as of October 25, 2018.

Companies (Bloomberg ticker)	**Geographical markets** (% of total revenues)	**Principal business segments** (% of total revenues)	**Weight** (in %)
Xinyi Solar Holdings Ltd. (968:HK)	China (80%) Others (20%) - represents 21% of the revenues from solar glass sales (includes the US)	Solar glass manufacturer (60%) Solar EPC services (25%) Solar farm business[2] (15%) **Total revenues**: 1,219 USD million	7.84%
GCL-Poly Energy Holdings Ltd. (3800:HK)	China (N/A) Others (N/A), - includes solar farm business and EPC in US	Electronic wafers manufacturer (73%) Polysilicon material producer (3%) Solar farm business[2] (19%) **Total revenues**: 3,657 USD million	3.54%
Beijing Enterprises Clean Energy Group (1250:HK)	China (≈100%)	Solar EPC services (81%) Solar farm business[2] (15%) **Total revenues**: 1,285 USD million	2.63%
China Singyes Solar Technologies Holdings Ltd. (750:HK)	China (89%) Others (11%) - includes the US	Solar EPC services[3] (75%); Mono-crystalline and Poly-crystalline PV panels and solar thermal products manufacturer (22%) Solar farm business[2] (5%) **Total revenues**: 872 USD million	2.59%
GCL New Energy Holdings Ltd (451:HK)	China (N/A) Others (N/A) - existent facilities in Japan and US and in development projects in Africa, Europe, Australia, Southeast Asia	Solar farm business[2] (37%) **Total revenues**: 606 USD million	2.26%
Solaria Energia (SLR:SM)	Spain (73%) Italy (20%) Latam (7%)	Solar farm business[4] (N/A) **Total revenues**: 37 USD million	2.74%
First Solar Inc (FSLR:US)	US (77%) Others (23%)	Solar EPC services (73%) Solar PV panels manufacturer (27%) **Total revenues**: 2,941 USD million	8.01%
SolarEdge Technologies Inc (SEDG:US)	US (57%) Europe (21%) Other countries (22%)	Power optimizers manufacturer (47%) PV inverters manufacturer (48%) **Total revenues**: 607 USD million	5.96%
Sunrun Inc. (RUN:US)	US (N/A)	Solar energy system leases (44%) Solar EPC services and sale of PV panels, racking systems, inverters and other solar products (56%) **Total revenues**: 530 USD million	5.85%
Atlantica Yield plc	North America (33%) South America (12%)	Renewable energy business including solar farm[4] (76%)	4.87%

[2] Solar farm business includes the revenues from electricity generation.
[3] Solar EPC services also includes curtain walls and green buildings.
[4] Solar farm business includes the revenues from electricity generation.

(AY:US)	EMEA (55%)	Efficient natural gas power (12%) Electric transmission (9%) Water (3%) **Total revenues**: 1,008 USD million	
Sunpower Corp (SPWR:US)	US (N/A) Other countries (N/A)	Solar EPC services and sale of PV panels, batteries, solar cells and other solar products (89%) Solar energy system leases (11%) **Total revenues**: 1,872 USD million	4.85%
Enphase Energy Inc (ENPH:US)	US, Canada, Mexico and other American markets (N/A), UK, France and other European markets (N/A), Australia, New Zealand, India and other Asian markets (N/A)	Solar EPC services (N/A) AC modules, microinverters, batteries and necessary software for solar systems manufacturer (N/A) **Total revenues**: 286 USD million	4.84%
TerraForm Power Inc (TERP:US)	US, Canada, Spain, Portugal, Chile, UK and Uruguay (N/A)	Solar farm business[5] (55%) Wind farm business[5] (45%) **Total revenues**: 610 USD million	4.67%
Canadian Solar Inc (CSIQ:US)	America (33%) Asia (57%) Europe and others (10%)	Solar farm business[4] and Solar EPC services (20%) Operation and maintenance services and sale of solar modules, PV batteries and other solar products (80%) **Total revenues**: 3,390 USD million	4.60%
Hannon Armstrong Sustainable Infrastructure (HASI:US)	US (≈100%)	Real estate investment and leases **Total revenues**: 106 USD million	4.64%
Vivint Solar Inc (VSLR:US)	US (≈100%)	Solar leases and incentives (56%) Solar EPC services (43%) Solar panels, batteries and other PV products manufacturer and Solar farm business (1%) **Total revenues**: 268 USD million	3.71%
Daqo New Energy Corp (DQ:US)	China (N/A) Other countries (N/A) - including the US	Polysilicon material producer (83%) Wafers manufacturer (17%) **Total revenues**: 353 USD million	3.18%
JinkoSolar Holding Co Ltd (JKS:US)	China, US, Japan, UK, Germany, France, Mexico, Brazil, the United Arab Emirates, India and other countries	Solar modules manufacturer (97%) Silicon wafers manufacturer (2%) Solar cells manufacturer (1%) Solar farm business[6] (0.05%) **Total revenues**: 4,069 USD million	3.08%
Scatec Solar ASA (SSO:NO)	Solar plants in operation: South Africa, Czech Republic, Rwanda, Jordan and Honduras and under construction: Egypt, Mali, Malaysia and Brazil	Solar farm business[6] (75%) Operation and maintenance (5%) Development and construction (20%) **Total revenues**: 182 USD million	5.23%
REC Silicon ASA[7] (REC:NO)	Taiwan (44%), China (24%), South Korea (11%), US (8%), Japan (5%), Europe (5%)	Polysilicon material producer (63%) Silane gas producer (35%) **Total revenues**: 272 USD million	2.73%

[5] Solar and wind farm businesses include the revenues from energy generation and incentives.
[6] Solar farm business includes the revenues from electricity generation.
[7] REC has factories in the US, that is why it will be considered a national manufacturer.

Meyer Burger Technology AG (MBTN:SW)	Asia (77%) Europe (19%) US (3%)	Solar EPC services (N/A) PV products such as solar cells, wafers and modules manufacturer (N/A) Specialized technologies out of the solar scope (N/A) **Total revenues**: 485 USD million	3.87%
Encavis AG (CAP:GR)	Germany (45%), Italy (30%), France (18%), UK (5%), Austria (2%), Denmark (0.2%)	Solar farm business[8] (74%) Wind farm business[7] (12%) Asset management (2%) PV service (2%) **Total revenues**: 266 USD million	4.89%
SMA Solar Technology AG (S92:GR)	Germany (15%) EMEA (37%) Americas (20%) APAC (27%)	Solar and battery inverters manufacturer (N/A) Complete solar system services (N/A) Storage systems (N/A) Monitoring and control systems (N/A) Maintenance services (N/A) **Total revenues**: 1,069 USD million	3.44%

Taking into account the principal business segments of the companies listed above and their relationship with the US, the following division into smaller groups was made. Note for the fact that Scatec Solar ASA, Encavis AG and Solaria Energia were not included in any group as they generate solar energy outside the US and it is expected that US energy policies do not affect them. Furthermore, Beijing Enterprises also does not operate in the US and has not any relationship with the country, so the same explanation as before was applied. Hannon Armstrong Sustainable Infrastructure was left outside of these groups as it is a REIT and does not belong to any of them.

Table 2. Division of the constituent companies between segments.

National manufacturers 21.54%	**Overseas manufacturers** 32.14%	**Solar energy generators** 11.80%	**EPC & leasing services** 27.26%
First Solar Inc	Xinyi Solar Holdings Ltd	GCL New Energy Holdings Ltd	First Solar Inc
SolarEdge Technologies Inc	GCL-Poly Energy Holdings Ltd.	Atlantica Yield plc	Sunrun Inc.
Enphase Energy Inc	China Singyes Solar Technologies Hold. Ltd.	TerraForm Power Inc	Enphase Energy Inc
REC Silicon ASA	Canadian Solar Inc		Vivint Solar Inc
	Daqo New Energy Corp		Sunpower Corp
	JinkoSolar Hold. Co Ltd		
	Meyer Burger Technology AG		
	SMA Solar Technology AG		

[8] Solar and wind farm businesses include the revenues from energy generation.

The group “National manufacturers” includes all the companies with factories in the US that have their core business as manufacturing solar related products, such as solar cells, solar panels and inverters. The overseas manufacturers refer to the manufacturing of the same products as before however they do not have their factories in the US and so they export their products to the country. The solar energy generators are the ones that generate energy in their solar farms located in the US as their core business. The EPC and leasing firms include all the firms that built solar farms and sell or lease solar panels and systems to clients.

3.2. Sample

The sample used was the price of the SUNIDX Index provided by the communication team of the index after entering into contact with them by email. The share prices of the different companies of the index were taken from yahoo finance.

For this thesis and as explained before, for the computed indexes, the sample period to be studied started on October 26, 2016, and ended on October 26, 2018. However, for the SUNIDX, to have a whole understanding of the index evolution, it was considered a more extensive sample period starting at the inception date, March 31, 2008, having already in mind that the prices fell shortly after due to the 2008 crisis.

3.3. Expected Results

Before presenting the graphics from the price evolution of the different indexes, firstly, it will be introduced the US policies and significant US events chosen that may affect them. Secondly, it will be discussed what the expectable impact from the policies in the indexes is. Moreover, it will be shown the graphs, in the section of results and verify if the effects occur as expected or not, in the discussion section. The following policies and events were the ones chosen to be studied next:

1. The US vs. China;
2. Obama administration’s policy: clean power plan and Obama’s war on coal;
3. 2016 US presidential campaign and Donald Trump’s election;

4. The acceptance and withdrawal of US from the Paris Agreement;
5. The US federal policies for solar companies.

From now on, every time that it is just written index, it is referent to the SUNIDX index. For the computed indexes, it will always be addressed their names in the texts.

3.3.1. The US vs. China

During the beginning of the century, there was historical cooperation on energy and environment between US and China, for example, with a ten-year framework developed in June 2008 and with seven clean energy initiatives implemented on November 2009. This cooperation permitted the solar value chain to get global and, consequently, allowed the solar companies to concentrate in one specific stage of the PV panel process, which then created numerous interactions between companies that specialized in the different phases of the process, by buying or selling their products to the others. In fact, the Chinese companies, by taking advantage of lower production costs, started to specialize in the manufacturing part of the solar PV cells and modules. They offered a lower price when compared to US manufacturers, which led to an increase in the imports of solar products from China to the US. The US government started to study this matter, on November 9, 2011, and concluded, on December 2, 2011, that Chinese companies were becoming more competitive than US producers because they were getting illegal and unfair subsidies from the government of China. After this conclusion, the US ignited a trade war with China by deciding to impose a preliminary tariff of 2.9% to 4.73%, on March 20, 2012, on Chinese manufacturers of solar cells and modules. However, this decision was already at the time predictable and did not surprise the investors, so it is not expectable a significant movement on the price trend that day. In the antecedent period, the prices may have fallen in the meantime mainly because of the uncertainty regarding the value of the tariff to be implemented and, also, because, even before the US started to study it, there were already news in the press on the beginning of October related to this theme.

On May 17, 2012, the US government decided to increase the tariff to 30% or more because they concluded that Chinese producers were putting their products in the US market illegally at a price

lower than the production cost. With this drastic and unexpected increase in the tariff, it is expectable an adverse change in the long-run index price trend, since Chinese manufacturers and US companies that usually import the solar panels from China would suffer high losses, even though national manufacturers (a small part of the index) would benefit a lot from this.

On October 10, 2012, US decided the value of the final tariff, differing from company to company, and the duty could be from 24% to 36%. It is not expectable a significant movement on the index price trend as the values of the tariffs did not change much from the previous one. Furthermore, on December 16, 2014, the tariff was expanded to Taiwan at 11.45% to 27.55% as Chinese companies were using PV cells manufactured in Taiwan to be able to import the products to the US and at the same time escape from the scope of the US tariffs.

On July 20, 2013, after an exactly one-year period since China announced the investigation against the US polysilicon manufacturers, the retaliation arrived with China imposing a tariff on imports from the US polysilicon manufacturers of 53.3% to 57%, to be implemented on July 24, 2013. With this measure, China expected an increase in its share in the worldwide polysilicon industry, aiming to be the leading global manufacturer of polysilicon in the future. It is expectable a disinvestment in the US polysilicon manufacturers companies as it was expectable a decrease in the production levels since a large part of the oldest share of the polysilicon produced by US companies would be transferred to China. The consequence in the SUNIDX index is unpredictable as it is bad for American and good for Chinese companies. Besides, mainly due to this tariff, on February 8, 2016, the Norwegian company REC Silicon announced that it would close one of the two factories based in the US. Regarding this specific company, it is expectable that its price trend would fall at the time of the announcement. However, it is not expectable significant variations in the SUNIDX index price trend as REC Silicon only weights 2.73% in the index.

During Trump's campaign, it was possible to conclude that, if Donald Trump won the election, the trade war would aggravate. After one year since Donald Trump started his functions as president of the US, the prediction was verified, on January 22, 2018, with Donald Trump announcing a new

tariff of 30% on imports of solar panels from China (being this tariff reduced to 15% after four years). Donald Trump approved this tariff after the International Trade Commission declared, on September 22, 2017, that the two national solar cells' producers (that do not belong to the SUNDX) were being damaged by the unfair competition from the Chinese manufacturers. The trade war between these two countries has negative impacts in all the companies so, after January 22, 2018, it is expectable a decrease in the long-run trend of all the smaller indexes prices, especially in the national manufacturers and in the overseas manufacturers, and, consequently, in the SUNDX price.

3.3.2. Obama administration's policy: clean power plan and Obama's war on coal

Despite, only, on June 2, 2014, EPA proposed a reduction of the global warming principally with a planned focus on decreasing the greenhouse gas emissions in the electric utility generators, already on May 26, 2014, there were news on the press about the proposal. The final version, disclosed on August 3, 2015, has an emission of carbon dioxide reduction target from 2005 emission level of 28% by 2025 and of 32% by 2030. This target would only be achieved if the shares of the sources to generate electricity would change drastically over the following years, in a way that coal and other fossil fuel-fired generators would need to lower their greenhouse gas emissions or even more extremely they would need to be disinvested and replaced by renewable energy generators. In these dates, investors would expect a better future for the solar industry and increase their investments in solar companies, so it is expectable an increase in the price trend.

On March 28, 2017, Donald Trump asked EPA to reevaluate the plan and on October 4, 2017, Reuters disclosed that EPA would repeal the Clean Power Plan in the near future which came to happen six days later on October 10, 2017, after continued leaks of potential alternatives elaborated by EPA in order to replace the original plan. As the alternative plans had rules weaker than before, investors may expect slower growth for the solar industry and retreat their positions on the market, being this behavior in line with a decrease in the price growth of the SUNIDX index, that might even be negative. It is expectable that the future of the constituent companies of the four computed indexes was affected and their prices decrease as well. However, the overseas manufacturers may

not suffer much damage as the worldwide solar industry is growing fast so if they do not export their products to the US, they will eventually sell them to other countries.

On August 21, 2018, Trump finally announced the already expected new plan with no reduction targets for the country. Besides the nonexistent targets, another notable difference between the two projects is the fact that Obama gave to EPA the ultimate power to regulate the emissions at a power plant level and also at a sector level while Trump gave only the ability to control the emissions at a specific power plant level. Nowadays, EPA cannot regulate the global emissions of the sector meaning, and unlike in the past, EPA has not the authority to require more RE companies in the sector. On the announcement date, there are not predictions of significant changes in the index price trend as investors already anticipated the announcement and the new plan and, in reality, investors may argue that the existent renewable companies were not harmed with Trump's scheme as the objective of this new plan is to boost the coal generators to improve the energy generation share of the US and not to substitute the already existent renewable energy generators.

3.3.3. 2016 US presidential campaign and Donald Trump's election

During the presidential election campaign of 2016 in the US, there was enormous uncertainty about who was going to win, only finished when the final result was known. The campaign period started when Hillary Clinton announced her already anticipated presidency's bid on April 12, 2015.[9] After many candidates and scandals, Hillary Clinton and Donald Trump were the nominees for being the president of US. The candidates did not spend much time discussing energy and environmental issues on their campaigns. However, when they did it, there were two distinct paths. From the Democratic Party, Hillary Clinton supported, like Barack Obama, a cleaner and carbon-free future for the US by promising a slowdown in using coal and oil as energy sources and increasing the shares of renewable energy in US while, from the Republican Party, Donald Trump promised a rollback on most of the Obama's energy and environmental policies. Donald Trump did not care

[9] Donald Trump announced his bid for the presidency on June 16, 2015.

about the sustainability of the planet, he just wanted the country to produce the most energy possible from all the existent sources in order to be less dependent from other countries. For example, he promised to remove the US from the Paris Agreement, to eliminate policies that limit oil and gas drilling, to restart coal extractions and also to eliminate bureaucratic issuers on innovation of other sources of energy, which might be good for the solar companies as it will decrease the costs but it might be dangerous as well as companies will lose their competitive advantages.

As the polls pointed to a victory of Hillary Clinton, the Trump's victory, on November 8, 2016, was a huge surprise which allied with his convictions against environmental sustainability, shown during the campaign, may have had adverse effects in the different renewable markets and, consequently, the price of the SUNIDX Index may have decreased after the election's day. However, during the campaign, as Hillary Clinton was the one always ahead in the polls and she supported the continuation of the Obama administration's policies regarding energy and environmental issues, the Index price should not change much.

3.3.4. The acceptance and withdrawal of US from the Paris Agreement

The United Nations Framework Convention on Climate Change (acronym: UNFCCC) is an environmental treaty adopted on May 9, 1992, signed between June 4, 1992, and June 19, 1993 (there were 166 signatures during this period, currently there are 197 parties), and implemented on March 21, 1994. According to Article 2 of the Convention, the final objective was defining a conscious level of the global greenhouse gas quantity in the atmosphere in order to not dramatically change the climate system. This measure should allow the ecosystems to adapt naturally to climate changes and it should also ensure the sustainable development of production. Also, in this Convention, more specifically in Article 7, it was created a Conference of the Parties, the supreme body, which has the power to adopt the best instruments to guarantee that the final objective of the Conference is achieved. Every year, since 1994, there is one Climate Change Conference and it was in the 1997 Climate Change Conference that the Kyoto Protocol, an extension of the UNFCCC,

was adopted. The Kyoto Protocol aimed to prevent global warming with the implementation of specific nation limits or commitments to reduce their greenhouse gas[10] emissions. It was signed between March 16, 1998, and March 15, 1999, and implemented on February 16, 2005. Although the US was one of the signatories and had a reduction commitment to 93% of the base year[11], the US did not ratify, accept, access or approve it and therefore the promise was left with no effect.

Furthermore, on the 21st meeting, COP 21 (usually designated as the 2015 United Nations Climate Change Conference, 2015 UNCCC, or CMP 11), the Paris Agreement was discussed and, in the last day of the Conference, on December 12, 2015, all the participants accepted the proposal. It was signed[12] between April 22, 2016, and April 21, 2017, and implemented on November 4, 2016. The Paris Agreement has the goal to reinforce the objective of the Convention in fighting against climate changes. For that purpose, and according to Article 2 of the Agreement, it was agreed the following: (i) the global average temperature should not increase more than 2ºC since the temperature levels of the pre-industrial period and measures to limit this increase to only 1.5ºC should be implemented too; (ii) the countries should increase their climate resiliencies and they should also pursue a sustainable future of low greenhouse gas emission; and (iii) the parties in order to achieve (ii), they should encourage investors to pursue the same pathway. Even though the US accepted, as previously announced by Obama, the Agreement on September 3, 2016[13], Donald Trump decided to retreat the country on June 1, 2017, as promised during his campaign and wrote on his Twitter account on the day before.

Mainly due to what was agreed in (iii), when the US accepted the Agreement and the following US in the Paris Agreement era, it was expected an increase in the trustiness of the investors on these companies as, to comply with what was approved, it was necessary more investment in the carbon-free energies. The highest trustiness should be reflected in an increase in the demand for these

[10] Carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6).
[11] The commitments can be seen in Annex B of the Protocol.
[12] The US signed on April 22, 2016.
[13] China also accepted it on this day. They jointly accepted it on the day before the G20 meeting in China.

companies' shares which consequently should increase the price of the SUNIDX index and the price of all the smaller computed indexes. On the contrary, when Donald Trump retreated the US from the Agreement, investors may have doubted about the future growth of the solar industry and reduce the exposure of their investments, which consequently should decrease the price of the indexes in the long-run.

3.3.5. The US federal policies for solar companies

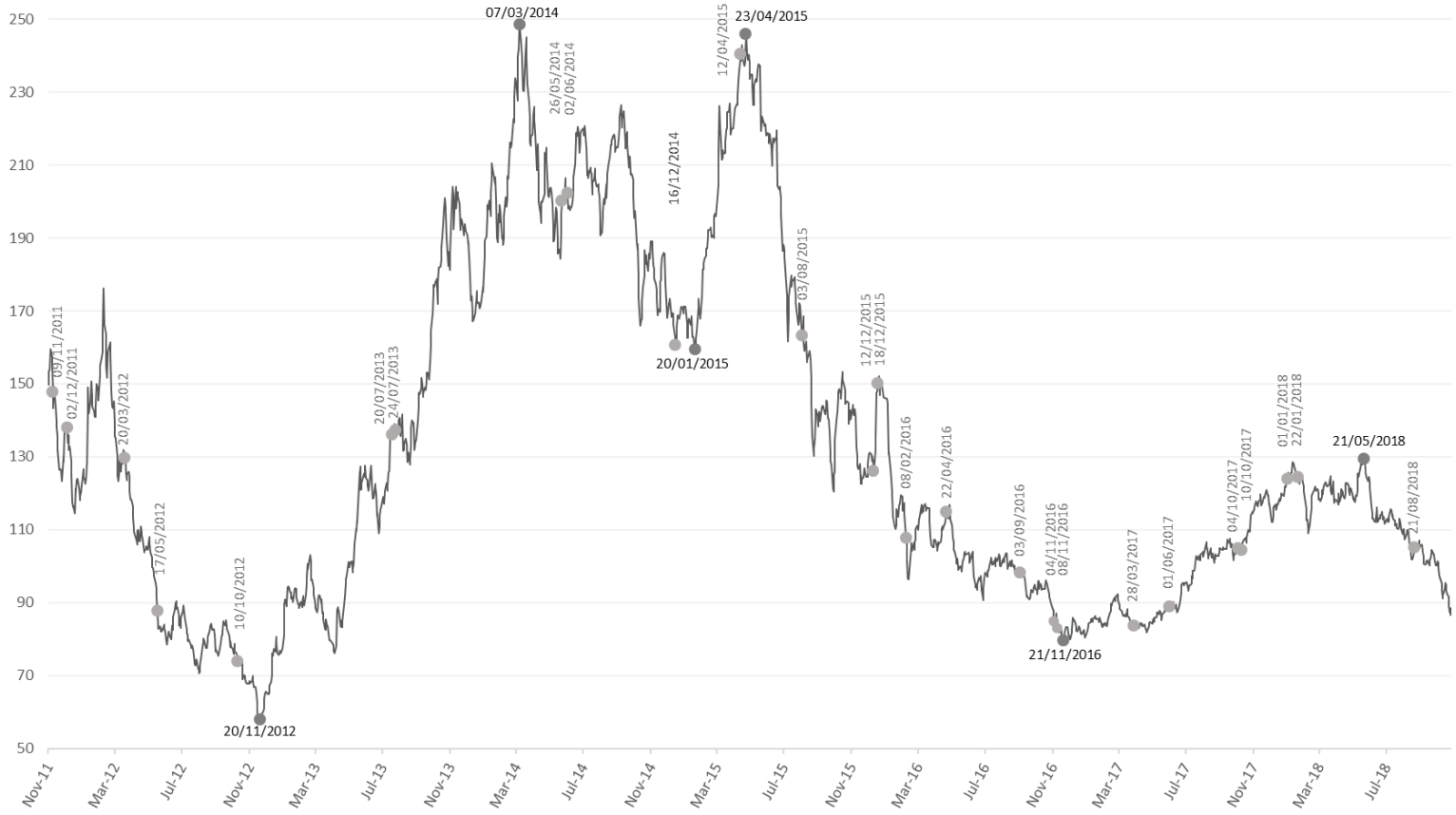
There are many RE policies in the US applicable at a state or national level, and they are also divided according to the different RE technologies. However, for this thesis, the ones that were considered significant, and will be highlighted next, are the US federal policies for solar companies:

- **Renewable Electricity Production Tax Credit (PTC)**: this policy was originated in 1992 and since then all the solar facilities whose construction began before January 1, 2018, had ten years of a tax credit, adjusted according to the inflation, for each kWh of electricity generated and sold to the grid. Investors may believe that there are fewer incentives for solar companies to decide to construct new facilities as, nowadays, they do not have access to this PTC. Concluding, with the end of the PTC, investors may believe that the capacity growth of the industry is being affected and, consequently, it is expected a decrease in the price trend of the index and, especially, in the price trend of the EPC & Leasing index.

- **Business Energy Investment Tax Credit (ITC)**: this policy was originated in 2005 and, after several amendments, it allows for all solar facilities whose construction starts until December 31, 2019, a deduction of 30% of the total expenditures from their federal taxes. The ITC will decrease four percentage points each year for the following two years and from 2022 onwards, the deduction will be only 10%. The last amendment for solar companies was on December 18, 2015, where the ITC was extended to the actual expiration dates (before that, the ITC would have expired on December 31, 2016). At this date, it is expectable an increase in the long-run price trend of the index as this extension would lead to higher growth in the solar industry.

4. Results

Graphic 1. Price evolution of the SUNIDX index since November 2011.



Graphic 2. Price evolution of the different computed indexes since October 2015.

5. Discussion

Looking at Graphic 1, it is easy to verify that between November 9, 2011, and October 10, 2012, it was a time of prices declination. For a more detailed analysis, it was computed a linear equation which gave a slope of approximately -0.18, meaning that the Index price decreased USD 0.18 per day in this period, on average. Furthermore, the arithmetic mean was USD 107.40 and the standard deviation was 27.50. During this period, which began with the US starting to study the trade situation between the US and China and ended with the US deciding the final tariffs to implement on the imports from Chinese companies, besides the unexpected tariffs imposed on imports, there were also many news coming out on how these tariffs would negatively affect all the companies, even the national manufacturers, creating a period of high uncertainty for the solar market.

Graphic 3. Price evolution of the SUNIDX between November 9, 2011, and October 10, 2012.

After this fall, on November 20, 2012, the Index started to improve. Then, on July 20, 2013, due to the Chinese retaliation, the growth stopped for a while and the prices even decreased. However, it quickly returned to grow again. On March 7, 2014, the growth ended and the index price fell sharply. These movements were not explained by any of the policies or events studied in this thesis. At the end of May 2014, the news related to Obama's Clean Power Plant started to appear on the press and the official announcement was made on June 2, 2014. With these events, the investors began to believe in a better future for the renewable industry and, consequently, the price of the SUNIDX Index started to improve as expected.

However, when the final version of the Clean Power Plant was made it available, on August 3, 2015, the index price did not improve as it was expected. In fact, it continued to decrease which may have happened due to another event negatively affecting the index.

Graphic 4. Price evolution of the SUNIDX between April 12, 2015, and November 8, 2016.

Regarding the expectations about the movement of the index during the US presidential campaign which started when Hillary Clinton announced her bid for the presidency, on April 12, 2015, and ended on the day of the Donald Trump's election, on November 8, 2016, they were completely incorrect. Rather than the expected increase, during this period, the index price declined USD 0.23 per day, on average. It can be explained by the high political uncertainty existent in the US during this period as there was enormous uncertainty about who was going to win which was only finished when the final result was known. Typically, periods of high uncertainty are reflected in all the markets into a period of prices declination. The fact that the market reacted in favor when Donald Trump was elected, despite all of his convictions about environmental sustainability, is due to the time of political uncertainty has finished.

Furthermore, another event that contributed to the reversal of the index price was, on November 4, 2016, the implementation of the Paris Agreement. This era will be further analyzed next.

Table 3. Statistical analysis of the three periods computed with the same number of prices: US Paris Agreement era, before the US accepting it, and after the retreating of US from the Agreement.

	Before accepting 09/12/2015 – 02/09/2016	**Paris Agreement** 03/09/2016 – 01/06/2017	**After retreating** 02/06/2017 – 27/02/2018
Arithmetic mean	109.63	86.94	109.07
Standard deviation	13.68	4.46	10.55

From this statistical analysis, two surprisingly conclusions can be taken: (i) the average price of the index during the US Paris Agreement era was lower than the mean in the period before accepting and after retreating and (ii) the volatility of the index, on the contrary, was lower when the US was in the Paris Agreement than in the other two periods. Contrary on the expected, the US is in the Agreement does not imply a better prospect for the future of the whole solar industry, so it was necessary to analyze the movement of the computed indexes and verify if there are specific parts of the industry which were beneficiated from the country being in the Paris Agreement.

Table 4. Arithmetic means of the computed indexes.

	Before accepting	**Paris Agreement**	**After retreating**
National manufacturers index	20.39	12.51	21.56
Overseas manufacturers index	13.83	9.90	15.20
EPC & Leasing index	17.93	10.20	14.88
Energy generators index	7.91	9.27	10.21

With this fragmentation, it is possible to verify that all of the average prices of the computed indexes during the Paris Agreement era were also lower except for the energy generators (represents only 11.8% of the SUNDX), which increased the average price from USD 7.91 to USD 9.27. This outcome may be explained if the manufacturers, with the strict rules to decrease the CO2 emissions, would need to improve their manufacturers process making them greener, which would increase their costs and in the final these companies would be damaged because of the Agreement.

Table 5. Standard deviations of the computed indexes.

	Before accepting	**Paris Agreement**	**After retreating**
National manufacturers index	3.57	1.15	4.66
Overseas manufacturers index	1.23	0.62	2.68
EPC & Leasing index	3.75	1.00	2.26
Energy generators index	0.76	0.38	0.56

Similar to the SUNIDX, all the standard deviations are lower when the US is a party of the Agreement. From this table, and also from the graphics, it is possible to understand that the national manufacturers are the companies which have more volatility, followed by the EPC & Leasing and overseas manufacturers. The energy generators show smaller price variations in the last two years.

This discussion ends with the analysis of the impact in the different indexes caused by the most recent US tariff on imports of solar panels from China. In the days after September 22, 2017, and, also, after January 22, 2018, the price of the index decreased. Regarding the smaller indexes, the same was observed in the index of the overseas manufacturers and the EPC & Leasing Index. On the contrary, the index of the national manufacturers showed an improvement in its price after Trump announced the tariff. The energy generators index, as said before, did not change much in the last two years and so there were no significant changes after these days.

6. Conclusion

It is possible to conclude, from this thesis, that investors are, most of the times, well aware of the implications of these studied policies and events on the future of the index constituent companies and the future of the solar industry in general since the indexes prices, usually, varied as expected when there were unexpected disclosures of news related to these themes. Furthermore, it was verified that the periods of high uncertainty, namely the periods before the decision of the implementation or not of a tariff on imports and, also, before the 2016 US Presidential Election, were the ones where the prices declined more. Although, the results from the Paris Agreement analysis were the ones that surprised more as when the US was a party of the Paris Agreement, the average price was below than the periods right before accepting it and after the retreating.

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Information regarding MAC Global Solar Energy Stock Index (SUNIDX) available in its website at https://macsolarindex.com/

Stock prices of the SUNIDX constituent companies available at https://finance.yahoo.com/

EU renewable energy targets available at https://ec.europa.eu/energy/en/topics/renewable-energy

EU renewable energy shares available at http://appsso.eurostat.ec.europa.eu/nui/submitView TableAction.do

US energy production by source available at https://www.eia.gov/totalenergy/data/monthly/ pdf/sec1_5.pdf

US energy transportation energy sources available at https://www.eia.gov/energyexplained/ ?page=us_energy _transportation

Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Proposed Rule available at https://www.gpo.gov/fdsys/pkg/FR-2014-06-18/pdf/2014-13726.pdf

Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Final Rule available at https://www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22842.pdf

The 1992 United Nations Framework Convention on Climate Change available at https://unfccc.int/resource/docs/ convkp/conveng.pdf

Ratification of the United Nations Framework Convention on Climate Change available at https://unfccc.int/ process/the-convention/what-is-the-convention/status-of-ratification-of-the-convention

Kyoto Protocol to the United Nations Framework Convention on Climate Change available at https://unfccc.int/ resource/docs/convkp/kpeng.pdf

Paris Agreement available at https://unfccc.int/sites/default/files/english_paris_agreement.pdf

ITC for Renewable Energy available at https://fas.org/sgp/crs/misc/IF10479.pdf

Business Energy ITC available at programs.dsireusa.org/system/program/detail/658

Renewable Electricity PTC available at programs.dsireusa.org/system/program/detail/734

114th Congress of the USA available at https://www.gpo.gov/fdsys/pkg/BILLS-114hr2029enr/ pdf/BILLS-114hr2029enr.pdf and **115th Congress of the USA** available at https://www.congress.gov/bill/115th-congress/house-bill/1892/text/eas2?q=%7B%22search%22%3A%5B%22bipartisan+budget+act+of+2018%22%5D%7D&r=1#toc-H2CA0A15EDA714CD3B7964CDED8037202

Annexes

Annex 1. Links for news regarding the different events analyzed in this thesis.

News about trade war between US and China:

https://www.theguardian.com/environment/2012/mar/20/us-imposes-tariffs-chinese-solar-panels

https://www.reuters.com/article/us-china-trade/u-s-sets-new-tariffs-on-chinese-solar-imports-idUSBRE84G19U20120517

https://www.nytimes.com/2014/12/17/business/energy-environment/-us-imposes-steep-tariffs-on-chinese-solar-panels.html

www.nytimes.com/2012/10/11/business/global/us-sets-tariffs-on-chinese-solar-panels.html

https://.ictsd.org/bridges-news/bridges/news/disputes-roundup-airbusboeing-and-us-china-solar-panel-conflicts-both

https://www.ictsd.org/bridges-news/bridges/news/us-china-solar-tensions-threaten-to-eclipse-environmental-trade-talks

https://www.reuters.com/article/us-china-trade/china-cries-foul-after-u-s-sets-tariffs-on-solar-imports-idUSBRE84H06O20120518

https://www.forbes.com/sites/williampentland/2016/02/08/china-scores-big-win-in-solar-trade-battle-as-rec-silicon-shutters-us-polysilicon-production/#44d10599269d

https://www.pv-magazine.com/2013/07/18/china-imposes-anti-dumping-duties-on-us-south-korean-polysilicon_100012085/

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https://www.cnbc.com/2018/01/16/cramer-china-trade-war-represents-the-top-three-risks-to-the-market.html

https://www.cnbc.com/2018/01/04/cramer-the-us-china-trade-war-could-explode-in-2018.html

https://www.forbes.com/sites/kenrapoza/2018/01/15/no-trade-war-with-china-barclays-predicts/#1909a4c5155e

https://www.bloomberg.com/news/articles/2018-12-29/egypt-forces-kill-40-militants-after-deadly-attack-on-tourists

https://solarindustrymag.com/trade-commission-votes-favor-suniva-solarworld/

https://www.forbes.com/sites/williampentland/2016/02/08/china-scores-big-win-in-solar-trade-battle-as-rec-silicon-shutters-us-polysilicon-production/#3f1cd847269d

News about Obama administration's policy:

https://www.nytimes.com/2014/05/27/us/politics/governments-await-obamas-move-on-carbon-to-gauge-us-climate-efforts.html;

https://www.livescience.com/46083-epa-carbon-emissions-proposal.html;

http://www.takepart.com/article/2014/06/02/epa-limits-coal-emissions;

https://www.vox.com/2014/5/29/5755070/EPA-carbon-power-plants-climate-change;

https://newrepublic.com/article/117902/epa-power-plant-regulations-faq-big-step-climate-change

https://www.forbes.com/sites/brianpotts/2018/08/22/whats-actually-in-president-trumps-diet-clean-power-plan/#234a1b7d3539

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https://www.theguardian.com/us-news/2018/aug/20/trump-coal-emissions-power-plants-rules-obama
https://www.reuters.com/article/us-usa-epa-climate/epa-replacement-for-obama-climate-plan-due-late-next-week-source-idUSKBN1L12CP
https://www.greentechmedia.com/articles/read/trump-clean-power-plan#gs.oiWWs1U

News about 2016 US presidential campaign:

https://www.telegraph.co.uk/news/2016/10/23/hillary-clinton-so-far-ahead-in-polls-that-doesnt-even-think-abo/
https://www.theguardian.com/us-news/2016/nov/09/how-did-donald-trump-win-analysis
http://time.com/4563685/donald-trump-wins/
http://time.com/4560399/hillary-clinton-donald-trump-final-day-polls/
https://e360.yale.edu/features/hillary_clinton_donald_trump_on_energy_and_environment_2016_presidential_election

News about Paris Agreement:

https://www.scmp.com/news/china/policies-politics/article/2008593/china-and-us-ratify-landmark-paris-climate-deal-ahead
https://www.reuters.com/article/us-china-climatechange-idUSKCN11901W
https://www.theguardian.com/environment/2016/sep/03/breakthrough-us-china-agree-ratify-paris-climate-change-deal
https://www.nrdc.org/experts/jake-schmidt/where-g2o-countries-stand-joining-paris-agreement
https://www.scientificamerican.com/article/u-s-and-china-formally-commit-to-paris-climate-accord/
https://www.washingtonpost.com/politics/trump-to-announce-us-will-exit-paris-climate-deal/2017/06/01/fbcb0196-46da-11e7-bcde-624ad94170ab_story.html?noredirect=on&utm_term=.ba491f3f3e97
https://www.theguardian.com/environment/2017/may/31/donald-trump-withdraw-paris-climate-change-agreement
https://www.theguardian.com/environment/2017/jun/01/donald-trump-confirms-us-will-quit-paris-climate-deal

Annex 2. Price evolution of the SUNIDX index since its inception date.